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(12) **United States Patent**
Zhang

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(54) **SINGLE-MODE OPERATION AND FREQUENCY CONVERSIONS FOR DIODE-PUMPED SOLID-STATE LASERS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(21) Appl. No.: **08/861,247**

(57) **ABSTRACT**

(22) Filed: **May 21, 1997**

Related U.S. Application Data

(63) Continuation-in-part of application No. 08/538,868, filed on Oct. 4, 1995, now abandoned, and a continuation-in-part of application No. 08/043,006, filed on May 28, 1993, now Pat. No. 5,515,394.

Key technologies have been developed in realizing single longitudinal mode CW operation with a regular standing-wave cavity for intracavity frequency doubling and intracavity frequency conversions, so as to produce all solid-state, true cw devices with operation over wide spectral ranges including green, blue and UV. In one method, a beam expander (23 or 41) is applied to render a large mode waist and an improved beam divergence so as to greatly reduce the insertion losses for intracavity optical elements (17, 18 or 44). In another method, when spatial hole burning effect is minimized by using a pump head (12) with a thin gain zone (2), then a low resolving-power spectral filter with low loss can be utilized. In addition, several novel optical multipass constructions, typically by use of total-internal-reflection, have also been devised for pumping laser chips, laser rods, laser slabs, and for the use of multipass optical amplifier and pumping fiber lasers.

(51) Int. Cl.⁷ **H01S 3/098; H01S 3/13**
(52) U.S. Cl. **372/19; 372/32**
(58) Field of Search **372/19, 32, 75, 372/101, 102, 106, 20**

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9 Claims, 18 Drawing Sheets

